SPACE DATA CORPORATION: AIR-TO-GROUND ANALYSIS

WT Docket No. 03-103
September 9, 2004

I. INTRODUCTION AND SUMMARY.

Space Data Corporation ("Space Data") responds to a series of questions posed by Commission staff addressing a number of proposed frequency allocation schemes under consideration in the pending air-to-ground ("ATG") services Notice of Proposed Rulemaking.[1] Proposed allocation schemes for the four MHz of ATG spectrum include: (1) two exclusive licenses (one 2.5 MHz license and one 1.5 MHz license); (2) two overlapping 2.5 MHz licenses; and (3) four overlapping 2.5 MHz licenses.

In this report, Space Data analyzes the feasibility of the Commission staff's proposal to assign two exclusive licenses for the provision of ATG services. The analysis includes issues that concern the implementation of the staff's proposal, such as interference between ATG licensees, the need for guard bands, and the transition of the legacy ATG network. In addition, Space Data comments on the overlapping license proposals put forth by AirCell and Boeing in this proceeding. Space Data suggests a compromise market-based auction approach that can include both the exclusive and overlapping license proposals. Space Data also responds to unsubstantiated, inaccurate and misleading claims that Boeing asserted in its July 13, 2004 ex parte challenging the viability and effectiveness of stratospheric platforms. As Space Data has demonstrated, stratospheric platforms are a unique and advanced technology that can be used to provide affordable, reliable and safe ATG services.

A licensing scheme that assigns two exclusive licenses for ATG services has several important advantages. First, it allows ATG service providers flexibility to scale their networks as market demand for ATG services increases. Exclusive use licenses also would be technologically neutral, permitting ATG operators to develop and use different types of networks, protocols and technologies to provide the most efficient and effective ATG services to consumers. Unlike overlapping license arrangements, assigning exclusive licenses would avoid the development and implementation of complex interference and sharing requirements. Furthermore, the Commission and ATG licensees would not require agreement on predetermined ground sites in order to avoid interference between overlapping licensees. An overlapping arrangement would significantly stifle the provision of ATG services. In addition, Space Data's analysis demonstrates that the smaller 1.5 MHz exclusive license can provide substantial voice and data services to airline passengers.

Although Space Data concludes that an exclusive license allocation would best serve the development of the ATG market and the public interest, other commenters support the use of overlapping licenses. As a possible compromise, Space Data proposes an alternative licensing

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[1] *Amendment of Part 22 of the Commission's Rules To Benefit the Consumers of Air-Ground Telecommunications Services*, Notice of Proposed Rulemaking, 18 FCC Rcd 8380 (2003) ("*ATG NPRM*").

scheme that allows the market to decide through a package bidding auction which licensing scheme presents the highest and best use of the spectrum. This approach would offer two exclusive 1.5 MHz licenses and two shared 1 MHz licenses. Through package bidding, a company seeking a 2.5 MHz exclusive license could bid on a package of both of the shared 1 MHz licenses and one 1.5 MHz exclusive license. On the other hand, companies seeking overlapping 2.5 MHz licenses could bid on a package of one 1.5 MHz exclusive license and one 1 MHz shared license.

II. THE COMMISSION STAFF'S PROPOSAL IS REALISTIC AND FEASIBLE FROM A TECHNICAL AND POLICY PERSPECTIVE.

As requested, Space Data has analyzed a Commission staff proposal that would divide the four MHz of spectrum currently allocated for ATG services into two exclusive licenses. The "A Block" license would assign 2.5 MHz (paired spectrum at 849-850.250 and 894-895.250) and the "B Block" license would assign 1.5 MHz (paired spectrum at 850.250-851 and 895.250-896).[2] Under this proposal, both A and B Block licensees would be required to provide ATG service (*i.e.,* service to airborne locations) on a primary basis, although the revised licensing and operating rules for ATG would allow broad technical and service flexibility. Space Data's analysis concludes that the staff's proposal is technically feasible and the most realistic to implement from a policy perspective of all other competing proposals outlined to date.

A. The Technical Parameters Of The Staff's Proposal Are Feasible.

1. The Staff's Proposal Allows ATG Providers To Scale Investment To Match Market Growth.

If the Commission seeks to allocate spectrum on an exclusive basis, the four MHz of spectrum that is available in the commercial ATG band allows at most two exclusive licensees. A variety of advanced technologies and services can be offered using the two exclusive licenses.

CDMA 2000 technologies require a minimum 2.5 MHz of spectrum. Accordingly, the A Block license could be utilized by an ATG licensee to provide a wide range of voice, data, or other type of wireless services to airborne consumers based upon this technology. Other commenters in this proceeding offered various technical approaches to implementing CDMA on 2.5 MHz of spectrum using terrestrial towers. CDMA technology also can be used to provide ATG service from a stratospheric-based network. A stratospheric network also can provide ATG service using other wireless technologies, such as iDEN or GSM.

One of the primary advantages of exclusive licenses is the ability to provide service over the entire United States with a capacity and investment that scales incrementally to match a growing but unpredictable market. Commenters' proposals to allow overlapping licenses that require rigid spacing rules for ATG sites will prevent needed operation and network flexibility. The current domestic ATG market has been estimated at $39 million for 6.5 million annual

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[2] *See* Letter from Cheryl A. Tritt, counsel to Space Data, to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket 03-103 (Aug. 26, 2004).

minutes of voice use.[3] Estimates of market potential, however, range from $510 million annual revenues for 900 million minutes of use (voice, SMS and data)[4] to $1.8 billion for 1,091 million minutes of broadband use.[5] If these predictions are correct, new ATG services could expand the capacity demands of the market by a factor of 138 to 168 times its current usage.

The Commission's efforts to bolster the ATG market, however, could fail if market projections are not met and ATG service providers are unable to scale down network infrastructure to be profitable in a smaller market.[6] In the commercial mobile radio system ("CMRS") context, networks have successfully responded to similar market conditions and predictions by initially building large cells, adding more channels to the existing cells as needed, and splitting the cells to increase capacity. With the limited ATG spectrum, one channel is available for CDMA technologies. Cell splitting would provide significant flexibility to scale a network to meet demand. Implementing a licensing scheme that will require a rigid spacing of ATG sites effectively eliminates market flexibility.

As an example of how ATG networks can be properly scaled to address cost and demand issues, stratospheric platforms operating on an exclusive 2.5 MHz license can initially provide coverage with only 3 sites at 100,000 feet (see Figure 1). The horizon from 100,000 feet to an aircraft at 10,000 feet is 821 kilometers (510 miles). CDMA technologies have the benefit of being adaptable to path delay in longer links by increasing the correlation length at the base station. The capacity demand of the current market is approximately 19,728 minutes of use per day (1644 planes with the legacy system each making an estimated six calls per day at two minutes per call). If this usage is spread over ten hours, the nationwide network must support 33 simultaneous calls. Even a single sector CDMA stratospheric platform could support up to 40 simultaneous calls, so even a minimal capacity network could support 3.5 times the capacity demanded by the current market. This can be done with minimal capital investment because only three sites are needed. The link budget for this approach is attached as Appendix A.

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[3] *See* AirCell Comments at 30 (July 27, 2004).

[4] *See id.* at 24.

[5] See Boeing Comments (April 29, 2004) at 20 and 21, showing 23.333 flights over 1 hour in length with more than 200 seats per weekday, 75% passenger loading, and a 20% penetration rate for ATG service. This combined with the $9.95 per 30 minutes pricing shown for Connexion (Boeing Comments, July 24, 2004) implies a market potential of: 23,333 flights * 200 seats * 75% loading * 20% penetration * 5 weekdays per week * 52 weeks per year * $9.95 per customer = $1,810,874,130.

[6] For example, in recent years a number of telecommunications ventures have halted operations because the market failed to meet projections, and infrastructure could not be scaled down to achieve profitability in a smaller market.

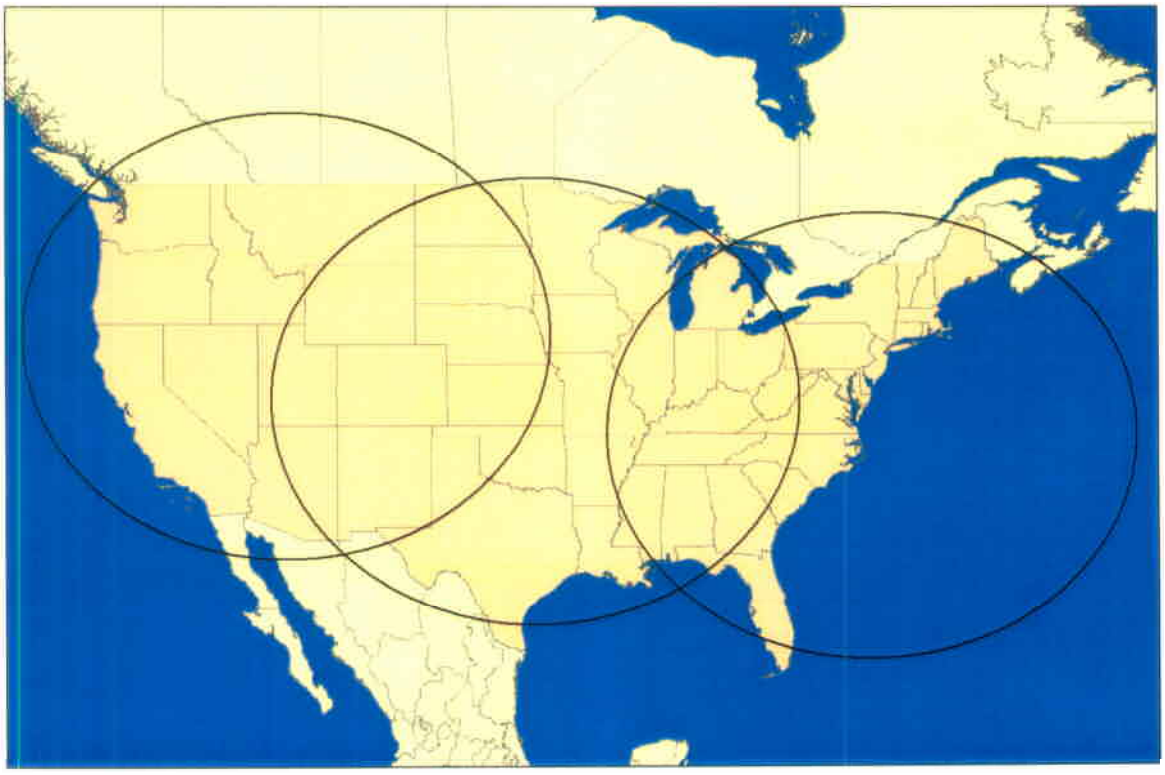

Figure 1: Minimal capacity ATG network using stratospheric platforms

If the ATG market meets the projections presented by other commenters, the ATG network(s) would need to support up to 40,000 simultaneous users as shown in Table 1. This capacity could be achieved by a constellation of 167 CDMA stratospheric platforms each with six sectors.

Table 1: Projected Capacity Requirements for National ATG Networks

DESCRIPTION	VALUE	UNITS	NOTES
Approximate seats on a 737	200	seats	4/29/04 Boeing comments
Seat load factor of 75%	150	passengers	4/29/04 Boeing comments
Penetration rate of 20%	30	customers	4/29/04 Boeing comments
Activity factor of 50%	**15**	**Concurrent users**	4/29/04 Boeing comments
Airborne commercial aircraft	2400	aircraft in CONUS	4000 craft x60% airborne - 6/03/04 Verizon comments
Average concurrent users on commercial aircraft	**36,000**		
Airborne corporate / private aircraft	2000		8000 craft x20% airborne - 6/03/04 Verizon comments
Est. concurrent users on corporate/private aircraft	2	Concurrent users	
Average concurrent users on commercial aircraft	4000		
Average number of CONUS concurrent users	**40,000**	**concurrent users**	

2. Use Of Stratospheric Platforms Under The Staff's Proposal Does Not Require The Need For Guard Bands.

A stratospheric ATG network, unlike a terrestrial-based network, also does not require spectrum for guard bands.[7] Guard bands are required to prevent "near-far" interference problems, which are not presented by an airborne platform. As shown in Figure 2, if an ATG operator elects to retain the legacy duplex scheme (*i.e.,* ground transmits on high band and the aircraft transmits at low band), B Block cellular towers could transmit on the channel adjacent to the aircraft transmitters. If a cellular tower is next to the ATG tower it is likely that the nearby cellular tower could saturate the ATG equipment trying to receive data from the aircraft. The ATG tower transmitter also could saturate the cellular tower base station radio trying to receive cellular handset transmissions on the adjacent channel as well as 800 MHz SMR Public Safety handsets trying to receive on the adjacent channel. These issues could be solved by either restricting the distance between ATG towers and B Block cellular towers that use incompatible protocols or by enhanced filtering on the affected ATG and cellular tower receivers.

As shown in Figure 3, if an operator elects to retain the duplex frequencies in the standard terrestrial manner of the aircraft transmitting in the low band and the base stations in the high band, then there is a potential near-far interference problem for cellular handsets receiving from a B Block cellular tower when near an ATG tower transmitting on an adjacent channel, as well as 900 SMR base stations trying to receive on an adjacent channel. This type of interference is more difficult to address because it is impractical to put filters on all cellular user equipment. This interference could be avoided by leaving a guard band or to prevent a cellular handset from getting near an ATG base station transmitting on the high band to an aircraft. The latter option is automatically accomplished with stratospheric platforms because the base station is miles above the ground and thus cellular handsets cannot get near the base station.[8]

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[7] Space Data is only one of several companies that are using stratospheric platforms to provide wireless services that could be utilized on the ATG band. For example, Sanswire recently announced that trials of its Stratellite high-altitude airship. "Sanswire Aims High On Wireless Broadband," RCA Wireless News, at 18 (Aug. 30, 2004).

[8] There also is the potential that an aircraft receiver near a B Block cellular tower will be saturated by the cellular transmitter on an adjacent channel. The aircraft would not be able to receive a signal from the stratospheric platform. This is not an issue in practice, however, because an aircraft would have to be on the ground to be near a cellular tower, and consumers would not be using ATG service.

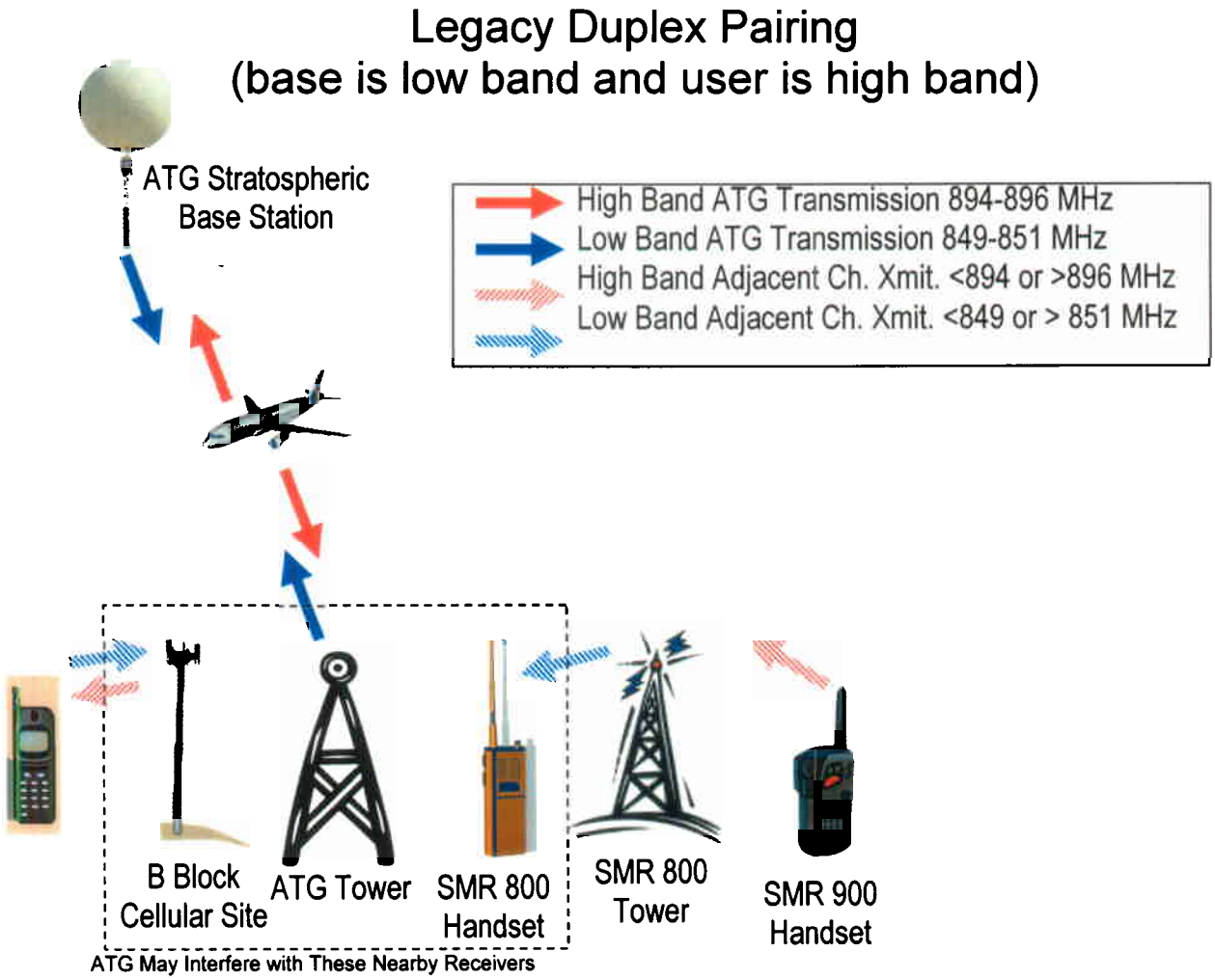

Figure 2: Legacy duplexing may cause near-far interference with B Block cellular base stations and 800 SMR handset receivers near ATG Towers if no guard bands are used.

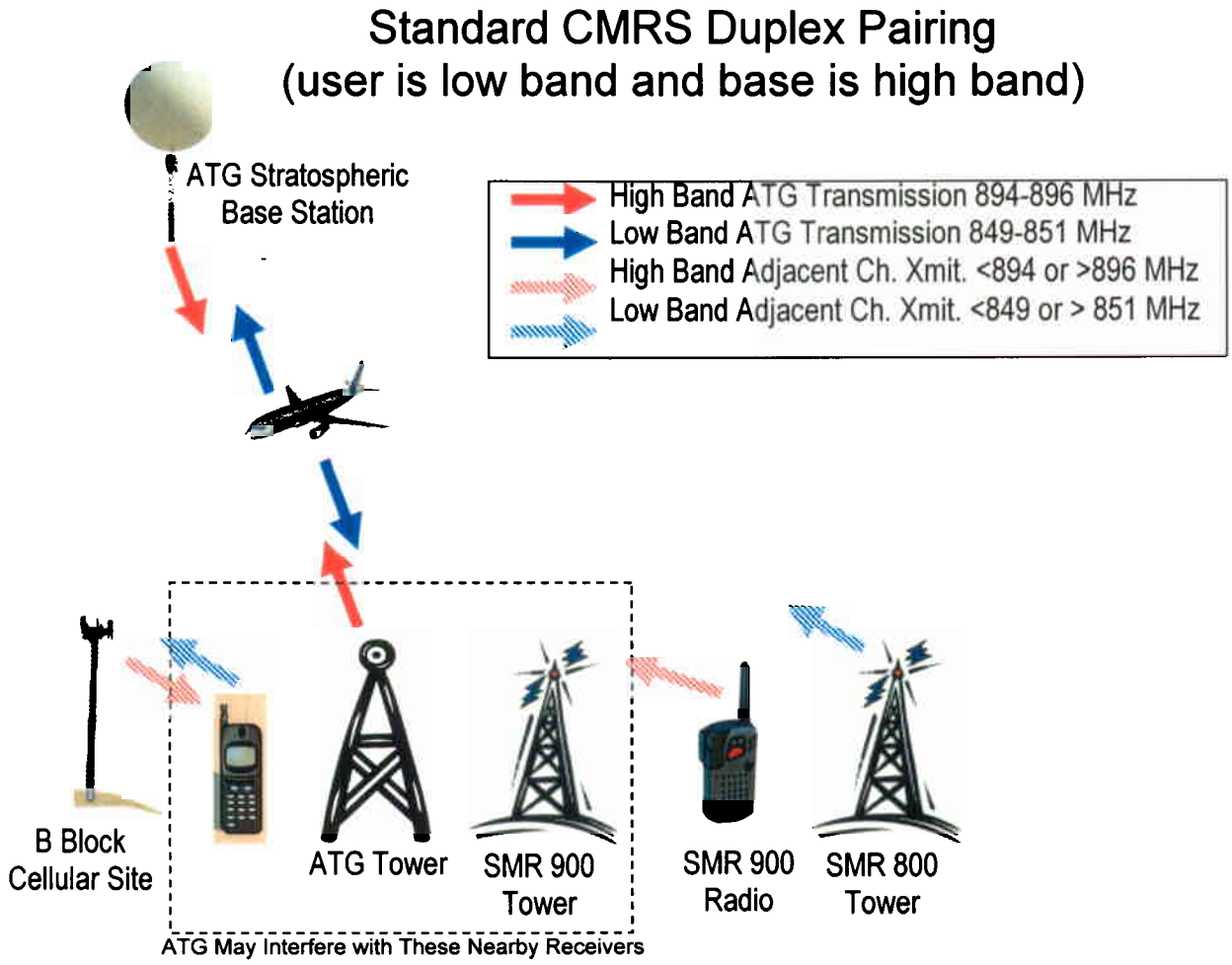

Figure 3: Standard CMRS duplexing may cause near-far interference with B Block cellular handsets and 900 SMR base station receivers near ATG Towers without guard bands.

3. A Variety Of Services Using Different Technologies Can Be Offered By The B Block Licensee.

The B Block license, which would be assigned exclusive use of 1.5 MHz of spectrum under the staff's proposal, could be used to provide a wide range of advanced wireless ATG services. For example, voice, Internet access, and SMS are just a few of the services that can be provided on the B Block license. Several narrowband technologies could be used to provide voice and packet data communications with iDEN and GSM, the most widely deployed. These narrowband technologies typically use time division multiple access ("TDMA") with timing restrictions that limit the maximum length of the link before bit collisions require that extra time slots be left open, thereby sacrificing capacity. For iDEN, this maximum distance is 112.5 km (70 miles). For GSM, this maximum difference is 37.5 km (23 miles).[9] The radius coverage

[9] Using GSM technology on the 1.5 MHz B Block license is technically feasible. GSM, however, requires 200 kHz paired channels. Thus a 1.5 MHz license would allow only three GSM channels

circle for each stratospheric platform is slightly larger due to the curvature of the earth and other geometry (130 to 145 km radius for iDEN versus the 112.5 km timing limit).

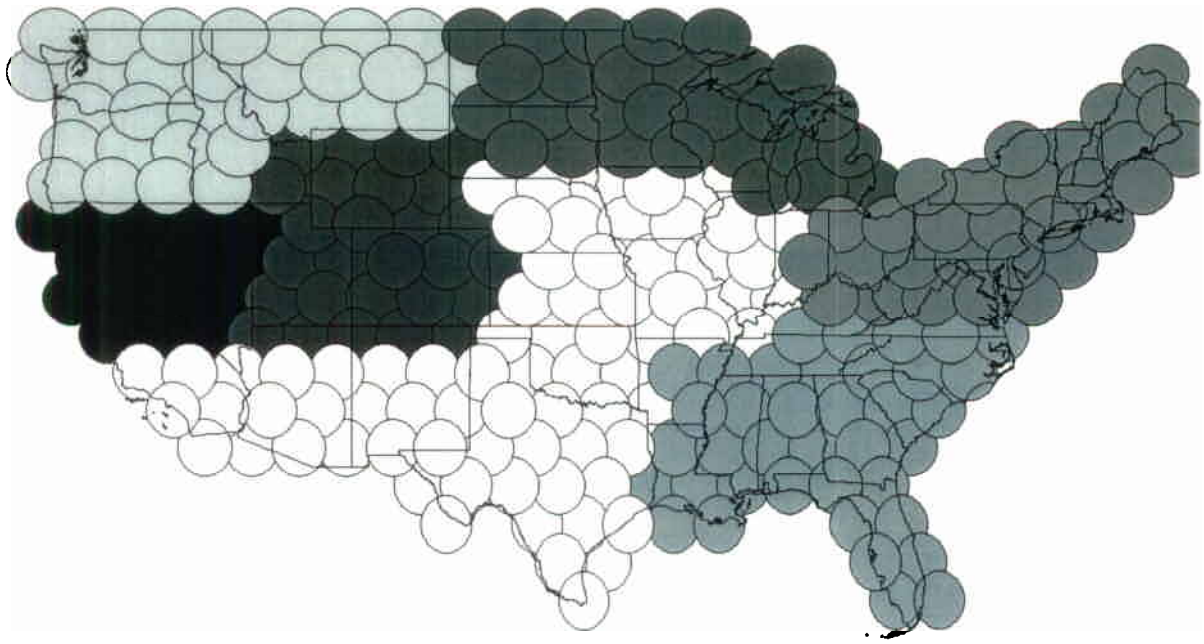

Figure 4: ATG network using 250 stratospheric platforms to provide iDEN service.

Figure 4 shows a constellation of 250 stratospheric platforms using iDEN. As iDEN uses 25 kHz paired channels, a 1.5 MHz exclusive license provides 30 channels. The minimum elevation angle for a stratospheric platform servicing an aircraft is significantly greater than that for terrestrial towers servicing subscribers. For example, a stratospheric platform at 120,000 feet is at least 80,000 feet higher than the commercial aircraft it services. At the edge of coverage, the elevation angle is at least 12.2 degrees. This compares to a terrestrial tower 200 feet tall providing a coverage diameter of 30 miles, which has a minimum elevation angle of 0.3 degrees. Each stratospheric platform has an array of seven antennas that project seven spotbeams as shown in Figure 5. Due to the large coverage radius of a stratospheric platform and the large elevation angles allowed by the height of a stratospheric platform, (combined with antennas with sharp roll offs), co-channel interference between stratospheric platforms is reduced to the point

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whereas it would provide 30 iDEN channels. With only three GSM channels, an antenna system with enough isolation between sectors would be needed to allow a reuse of three. With steeper downlook angles of antennas from stratospheric platforms relative to towers this may be possible. However, as GSM provides up to 16 calls per channel with half rate vocoders and iDEN provides up to six calls per channel, a GSM network with a reuse of three would have only 60 percent of the capacity of an iDEN network with a reuse of seven assuming the same number of sectors in each network. Sharing spectrum between a GSM ATG network and the legacy ATG network during a transition period would only leave 300 kHz for the legacy ATG network, which only allows for 20 legacy communications channels and six legacy control channels. This may not be a sufficient number of channels for the legacy ATG network, even with its current low utilization.

that frequencies can be shared between stratospheric platforms as long as the spot beams are separate frequencies. This provides 28 available channels split between seven beams or four channels per spot beam. Because the number of stratospheric platforms can greatly exceed the number of terrestrial towers described in this proceeding, it is more appropriate to determine the capacity of the total system rather than by sector. In addition, because stratospheric platforms are not limited to a fixed grid or current tower locations, new stratospheric platforms can be launched to form tighter spacing to increase capacity as needs change. Table 2 shows that the capacity of this network is adequate to serve the entire projected ATG market. As the market would be shared with the ATG A Block licensee, this stratospheric iDEN network would have extra capacity to service terrestrial subscribers outside of tower coverage on a secondary basis.

Since the horizon from an aircraft at 10,000 feet is 70 miles with the aircraft one degree above the horizon, an iDEN terrestrial network could be implemented with 250 terrestrial towers. A similar capacity to the stratospheric network would be achieved. The ability to communicate directly to a passenger's handset in a window would be impaired with the tower based network. However, cabin mounted equipment could be used linked to a belly mounted antenna. The tower-based network would also not provide complete coverage below 10,000 feet like the stratospheric-based system does. Thus, terrestrial networks also can effectively utilize the 1.5 MHz exclusive use license.

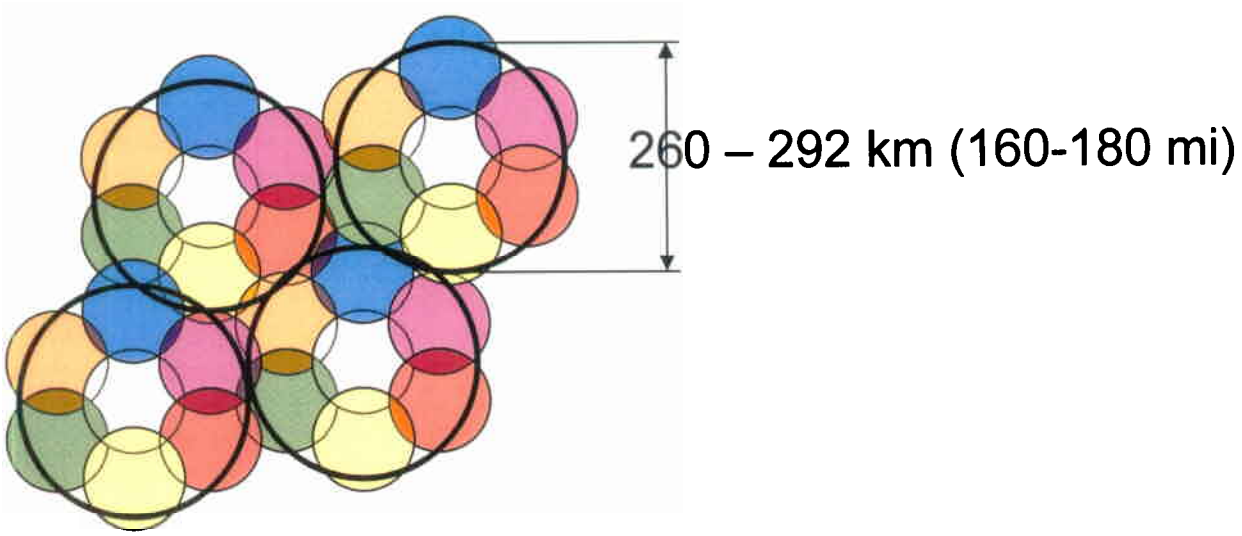

Figure 5: Each Stratospheric platform projects seven spotbeams. The 28 of the 30 available frequencies are used in a reuse pattern of seven with each color representing a set of four frequencies.

Table 2: Capacity of a stratospheric-based iDEN network capable of servicing the ATG demand derived in Table 1 using a 1.5 MHz exclusive use license.

Stratospheric Network Capacity

Voice channels per physical channel	6	subchannels
Spotbeams per High Altitude Platform	7	spotbeam
Physical channels per spotbeam	4	channels
Voice channels per spotbeam	23	Voice channels
Per Stratospheric Platform	161	Voice channels
CONUS voice channel capacity	**40,250**	**voice channels**
or	**101%**	**of the existing CONUS market**

The same guard band issues discussed above in the 2.5 MHz license context apply to the 1.5 MHz channel. In summary, guard bands are not needed with stratospheric-based ATG networks because the base stations and aircraft are never close enough to receivers on adjacent channels to cause near-far interference.

If narrowband technologies are used on a tower-based ATG system, however, guard bands would be needed. An advantage of narrowband technologies for tower-based ATG networks is that the required guard bands are greatly reduced relative to CDMA technologies because the emission masks are narrower. Figure 6 shows the power versus frequency plot for Motorola's TDMA Modulation used in iDEN.[10] Figure 7 compares this to the power plots submitted to the record by Flarion and Qualcomm.[11] Note that the power of the iDEN signal drops off much more rapidly than either the CDMA or the Flarion signals. Thus, the guard bands required for narrowband technologies such as iDEN can easily fit within the 1.5 MHz B Block license. Again, guard bands are only needed for tower based operators as the signal level from a stratospheric platform is attenuated to a fairly low and uniform level by the time it reaches the earth.

[10] *See* "iDEN Technical Overview", at 3-5 available at https://idenonline.motorola.com/ideveloper/pdf/techover.pdf

[11] See Letter from Michael J. Thornton, Flarion Technologies, Inc. to Marlene H. Dortch, Secretary, Federal Communications Commission, at 2, WT Docket No. 03-103 (Sept. 2, 2004); Letter from Dean R. Brenner, Qualcomm Inc., to Marlene H. Dortch, Secretary, Federal Communications Commission, at 1, WT Docket No. 03-103 (Sept. 3, 2004).

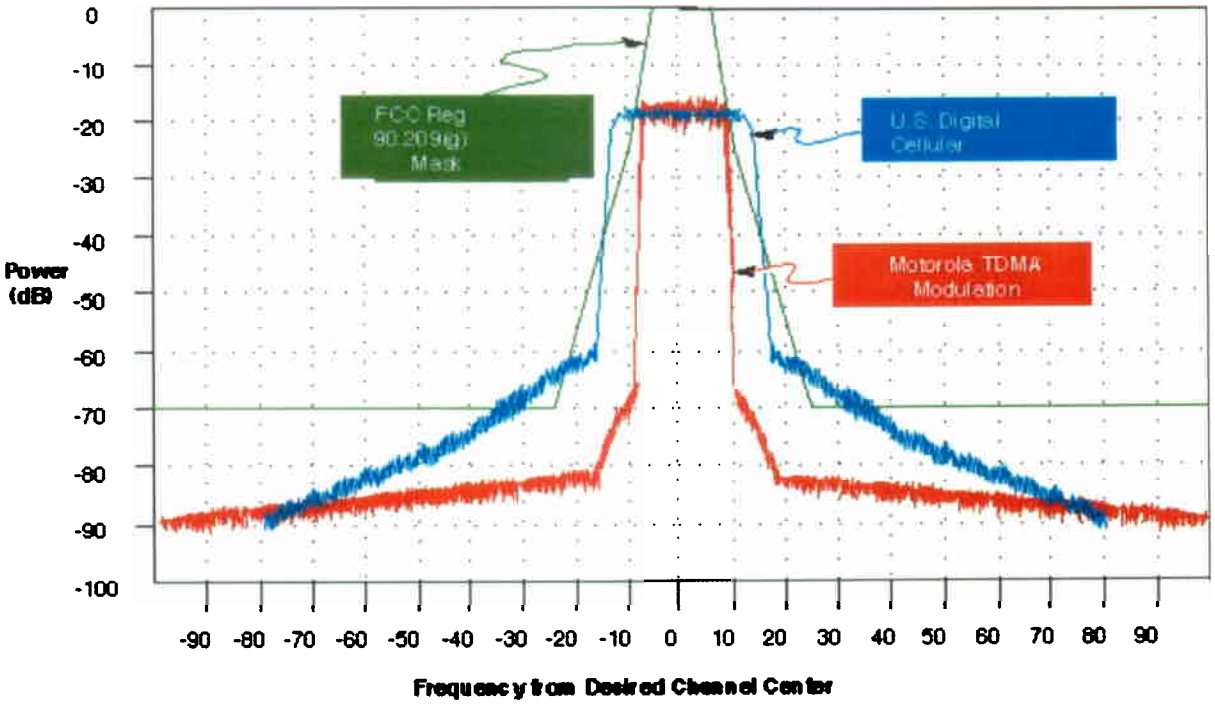

Figure 6: Power versus Frequency plot for iDEN.

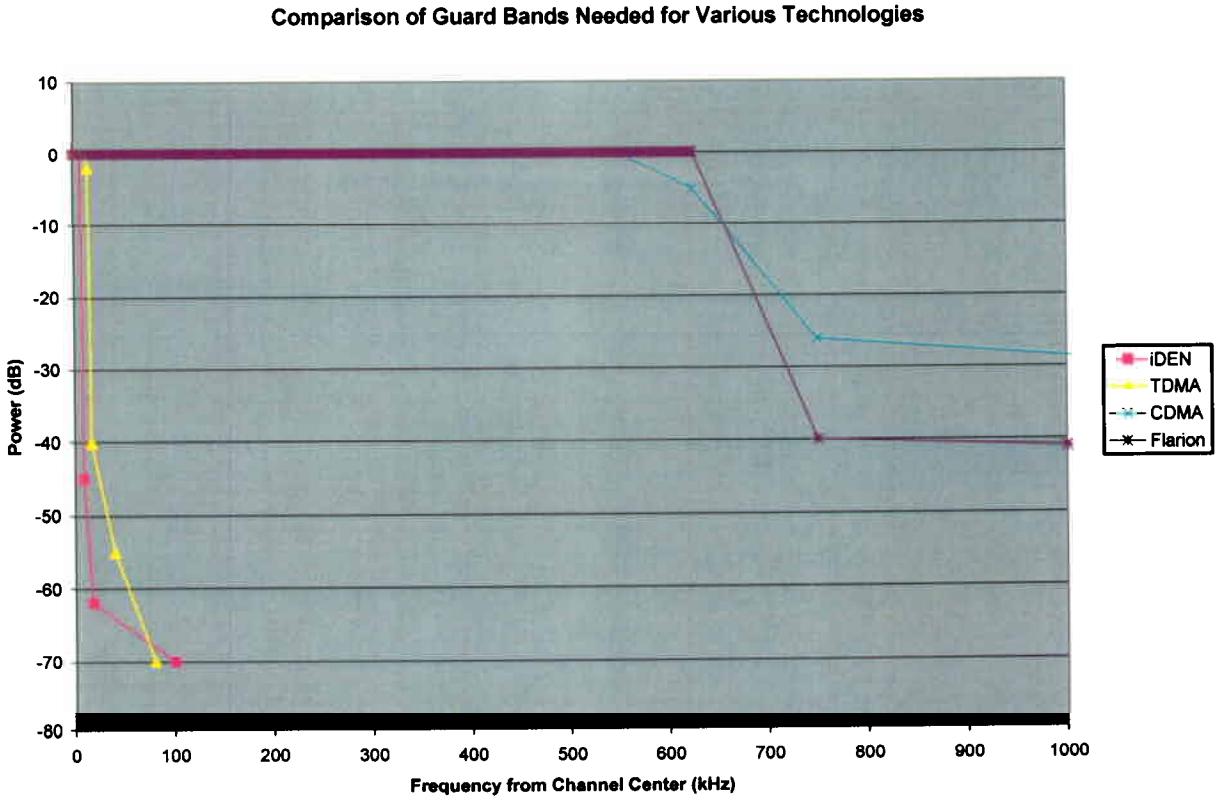

Figure 7: Comparison of guard bands needed for various technologies.

4. The Incumbent's Operations Would Be Adequately Protected Under The Commission Staff's Proposal.

The Commission staff's proposal provides adequate protection to the incumbent's legacy system during a transition to a new licensing scheme. Based on reported traffic for the legacy ATG network, it appears that the 1.5 MHz exclusive channel provides sufficient spectrum for the legacy ATG network to operate in coordination with the start of a new ATG network in the B Block during its wind down phase. On page three above, Space Data noted that the legacy ATG network's traffic is approximately 33 simultaneous calls across the country. To ensure that the legacy ATG network has enough capacity to handle peak hour call rates, Space Data assumes the incumbent needs twice this level of capacity. From the Geographical Channel Block Layout table in Section 22.859 of the Commission's rules, each of the ten legacy frequency blocks is reused between nine and 12 times across the country. Taking the minimum reuse of nine would result in eight 6 kHz legacy communications channels being required to service the 66 required calls nationwide. In addition, we assume that the legacy ATG network will require eight 3.2 kHz control channels. Together, this is a total of 8 * 6 + 8 * 3.2 = 73.6 kHz of spectrum for ground stations and the same for aircraft. Thus, the legacy network could be allocated 150 kHz of the 1.5 MHz exclusive channel to support its current operations during the transition period. This leaves 90 percent of the channel for the B Block licensee to start ramping up operations. In the example of stratospheric platforms delivering iDEN services, it is unlikely that four base radios per spot beam would be deployed initially as the market will need time to develop from its current 6.5 million minutes of use per year to the projected unmet demands of hundreds of millions of use per year. It also will take time for compatible user equipment to be adopted. Thus, for the first two years the system could be operated with three channels per beam and this would provide 25 percent of the 1.5 MHz block (375 kHz) for the legacy ATG network during the transition. Because this is more than twice the spectrum that appears to be needed for the current legacy ATG operations, it provides some margin for guard bands if needed by a new tower-based ATG operator in the B Block.

Both the A and B Block licenses would be assigned through an auction. Possible outcomes of the auction include: (1) incumbent Verizon Airfone is the high bidder for the A Block license; "company X" is the high bidder for the B Block license; (2) Verizon Airfone is the high bidder for the B Block license; "company X" is the high bidder for the A Block license; or (3) Verizon Airfone is not the high bidder for either the A or B Block licenses.[12] As discussed below, to ensure a competitive ATG market, the Commission should impose cross ownership limitations on the A and B Block licenses.

If the Commission concludes that the legacy network must be protected, Verizon Airfone could temporarily move its legacy network to B Block license frequencies. Under the first scenario assuming Verizon is the high bidder for the B Block license, it could move its operations to those frequencies and either continue operating its legacy system or upgrade its ATG network. Verizon Airfone has stated its intent to deploy a new system using more advanced technologies, if it continues to provide ATG services.[13] Thus, under the second

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[12] Under a fourth scenario, Verizon Airfone could be the high bidder for both the A and B Block licenses. Space Data strongly urges the Commission to require that unaffiliated entities hold the two ATG licenses.

[13] *See, e.g.*, Comments of Verizon Airfone at 9-15, WT Docket No. 03-103 (Sept. 23, 2003).

scenario assuming that Verizon Airfone is the high bidder for the A Block license, it could continue to operate its legacy system in the A Block while it upgrades its network. If the Commission concludes that it is not technically feasible for Verizon Airfone to operate its narrowband legacy network in the same frequencies as its new network, Verizon Airfone could be permitted to operate its legacy system on the B Block frequencies for a fixed period of time (not to exceed two years) to phase out that system.[14] Similarly, under the third scenario assuming that Verizon Airfone is not the high bidder for either ATG license, the legacy system could operate on the B Block frequencies and be phased out over a fixed period of time.[15]

Under either the second or third scenarios, the Commission should provide Verizon Airfone with no more than two years in which to transition its legacy system to the B Block and then subsequently vacate those frequencies. Two years would be more than sufficient to transition its network given that Verizon Airfone is already developing its new network, and the two-year period will not start immediately, because the Commission must still develop service rules for the ATG band. Therefore, the B Block frequencies would be encumbered for this limited period by the incumbent's legacy network. Upon expiration of the transition period, the B Block licensee would have exclusive rights to this spectrum.

B. Adoption Of The Staff's Proposal Would Serve The Public Interest.

The Commission staff's proposal to allocate two exclusive licenses for ATG services satisfies the Commission's stated goal in restructuring the ATG band to "provide greater opportunities for the competitive provision of air-ground services, leading to lower prices to consumers and increased choices in wireless services and enhancements."[16]

The current annual revenue for commercial ATG services is less than $50 million.[17] Although the Commission initially anticipated up to six providers in this market, the cost of developing, deploying and maintaining dedicated ATG networks has been a significant barrier to entry in a market with a limited customer base. Despite increasing consumer interest in ATG services, the market remains untapped because it is too inconvenient and costly for airline passengers to utilize the existing service.[18] The introduction of vigorous competition in the ATG market would require service providers to operate efficiently and to offer reasonably priced and new and innovative services to customers. Allocating two exclusive licenses for the provision of ATG services ensures a level of competition that is currently absent from the market while

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[14] Based upon Verizon Airfone's existing minimum capacity requirements, Space Data questions why Verizon Airfone could not operate its legacy system on the same frequencies that it presumably would deploy its new system.

[15] Rather than phasing out its legacy network, Verizon Airfone could choose to sell it to the B Block licensee.

[16] *ATG NPRM,* 18 FCC Rcd at 8389.

[17] *See* Reply Comments of Space Data, WT Docket No. 03-103, at 6 (Oct. 23, 2003).

[18] American Airlines recently noted in an ex parte filing that the demand for on-board data services is steadily increasing. *See* Letter from Rich Farr, Senior Manager, Radio Communications, American Airlines, to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 03-103 (Aug. 30, 2004).

avoiding flooding the market with so many service providers that none gains a sufficient customer base to effectively compete and efficiently provide service.

Furthermore, licensees would be more likely to invest in and deploy advanced ATG networks if their operations are not subject to complex sharing arrangements with other ATG networks. Exclusive ATG licenses also would have greater flexibility in using different types of technologies, whether they are terrestrial, stratospheric, or a combination of both. On the other hand, sharing or overlapping systems may limit the types of technologies and protocols used to provide ATG services. Exclusive licenses also better limit potential interference between ATG service providers.

Any modifications to the licensing scheme for the ATG band will require revisions to the Commission's ATG service rules, codified in Part 22 of the rules. The staff's exclusive license proposal would be fairly straightforward to implement. The rules should reflect basic licensing requirements (*e.g.*, frequency allocations for the A and B Block licenses, build-out requirements if the Commission so chooses) and a transition period for the incumbent to move and/or phase out its legacy ATG network, all of which would be necessary under any new licensing scheme. Otherwise, the ATG service rules would not need to impose specific technical limitations on ATG service providers. As noted above, the service rules also may not need to provide guard bands under the staff's proposal. Rather, under the staff's proposal, the rules can allow licensees the flexibility to use different technologies and equipment to provide a wide variety of services to airborne consumers on a primary basis.[19] Such flexibility in the Commission's regulatory policies has proven effective in the CMRS market, contributing to the rapid growth of new technologies and services in the terrestrial wireless market. The Commission now has the opportunity to implement the same flexibility in the ATG market to the ultimate benefit of consumers.

C. Cross-Ownership Restrictions Are Necessary To Ensure A Competitive ATG Market.

To ensure competition in the ATG market, the Commission must adopt a cross-ownership restriction that prohibits one entity (or two affiliated entities) from holding both the A and B Block licenses. As Space Data demonstrated in its Reply Comments, competition is a powerful force in making telecommunications services accessible and affordable to consumers. If one company is allowed to monopolize ATG service, the current dysfunctional market scheme would remain unchanged and airborne consumers would lack access to competitively priced ATG services.

The licensing scheme in the ATG market is analogous to other wireless services that, in their infancy, required some limitation on ownership in order to ensure competition. For example, in the in CMRS market, the Commission in the mid-1980s adopted rules prohibiting cellular carriers from controlling both cellular licenses in a geographic area. Such restrictions were necessary "to guarantee the competitive nature of the cellular industry and to foster the

[19] The Commission's ATG service rules should also promote spectrum efficiency by not prohibiting potential secondary uses of the ATG frequencies, so long as the secondary uses do not cause harmful interference to the ATG services.

development of competing systems."[20] The Commission also adopted cross-ownership restrictions of cellular and PCS licenses and caps on the amount of CMRS spectrum that may be held within a geographic market. The Commission only recently relaxed its ownership restrictions.[21] The Commission removed the restrictions because the CMRS market had become highly competitive and the ability of a carrier to monopolize a market had been neutralized. Now, consumers can choose from five to seven service providers for terrestrial wireless services in the vast majority of markets.

Similar to the terrestrial wireless market when it was in its infancy, the ATG market requires some limitation on one carrier holding both the A and B Block licenses under the staff's licensing proposal. Such a restriction is necessary to ensure the development of competition and competing systems in the ATG market. Only one service provider currently operates in the ATG market, and intermodal competition, such as Boeing's Connexion service, is still in its infancy and should not be relied upon to be the sole competitive alternative to a monopoly ATG provider.

III. AN OVERLAPPING LICENSING REGIME WOULD BE CUMBERSOME TO IMPLEMENT.

AirCell and Boeing have proposed various licensing schemes in which two to four licenses would be allocated in the ATG band, but would share certain frequencies with at least one other ATG license. Any benefits of an overlapping license scheme in terms of allowing potentially up to four competitors using the ATG band are arguably outweighed by the technical and administrative difficulty in implementing these complicated licensing schemes.[22]

The spectrum sharing proposals rely on exact spacing of base stations to eliminate base station-to-base station interference. Therefore, the Commission would need to regulate how and where ATG licensees deployed ground stations. These regulations could become even more difficult to craft and implement if each ATG system uses different technologies and protocols to provide ATG service.

Moreover, adopting a licensing regime in which ATG licensees share spectrum will necessitate developing and implementing a wide range of sharing requirements. Such

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[20] *See, e.g., Amendment of the Commission's Rules To Allow the Selection from Among Mutually Exclusive Competing Cellular Applications Using Random Selection or Lotteries Instead of Comparative Hearings*, 98 F.C.C.2d 175 (1984).

[21] *See 2000 Biennial Regulatory Review Spectrum Aggregation Limits for Commercial Mobile Radio Services*, 16 FCC Rcd 22668 (2001) (sunsetting the Commission's spectrum cap rule and eliminating the cellular cross-interest rule in metropolitan areas); FCC News Release, *FCC Adopts Measures to Increase Rural Investment and Facilitate Deployment of Spectrum-Based Services in Rural Areas*, WT Docket Nos. 02-381, 01-14, 03-202 (July 8, 2004) (eliminating the cellular cross-interest rule in rural areas) (text of order is not yet publicly available).

[22] In a June 10, 2004 ex parte, Space Data initially believed that AirCell's spectrum-sharing proposal could be a viable licensing scheme for the ATG band. Upon further analysis, however, Space Data concludes that the exclusive license approach proposed by the Commission staff is the better approach to ensure technical flexibility and promote competition in the ATG market.

requirements will take a significant amount of time to develop and implement, which would unnecessarily delay deployment of ATG services to airborne consumers. For example, ATG service providers with overlapping systems would likely require directional antennas and specialized tracking software to minimize interference between overlapping ATG systems.[23] Specialized network equipment also will need to be developed to account for sharing spectrum, which may be costly and time-consuming.[24] ATG service providers also would likely be subject to modulation limits and any number of technical sharing requirements due to using reverse polarization and reverse banding.[25]

Each of the requirements listed above would apply to an overlapping two or four-license scheme. The need for coordination between licensees and networks, and thus Commission regulation and possible intervention, would necessarily increase as the number of licensees operating in the ATG band increases.

Whether an overlapping approach would be viable also is questionable considering the initial allocation for ATG frequencies was based upon a sharing plan among six licensees, which the Commission has acknowledged was largely unsuccessful.[26] The Commission's existing ATG rules are highly technical and do not allow for technical flexibility because the initial allocation was based upon the six licensees sharing frequencies, necessitating significant coordination of ground stations and other technical requirements. There is no reason to believe that reassigning the ATG spectrum to overlapping licenses is going to produce a different result.

In addition to the technical requirements that would be triggered by overlapping licensees, sharing frequencies could significantly limit the technologies that ATG licensees could utilize to provide ATG services. Regulatory policies that promote the use of different technologies and equipment, however, have contributed significantly in the development of terrestrial wireless services. Overlapping systems in the ATG service could prevent an ATG licensee from using a particular technology or protocol if the overlapping system interfered with the other licensee(s).

If one ATG licensee deployed its network prior to another licensee, the second licensee also could be at a significant disadvantage if it had to conform its network to that of the first licensee. Similarly, an ATG licensee that later decided to upgrade its network to take advantage of new technologies and equipment could only do so if the modifications did not adversely affect the network of another licensee. As a result, licensees would need to synchronize the development of their networks, which would limit the operational and competitive choices of all licensees.

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[23] *See, e.g.*, Telcordia Technologies Presentation, "Coexistence Analysis for Multiple Air-to-Ground Systems (Apr. 9, 2004), attached to letter from David E. Hilliard, counsel to Verizon Airfone, to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 03-103 (Apr. 12, 2004).

[24] *Id.*

[25] *Id.*

[26] *See ATG NPRM*, 18 FCC Rcd at 8384.

IV. THE FCC CAN UTILIZE A MARKET-BASED APPROACH TO DETERMINE WHETHER EXCLUSIVE OR NON-EXCLUSIVE LICENSES ARE ALLOCATED.

The Commission is evaluating two ATG licensing schemes: (1) exclusive licenses assigned to a 2.5 MHz frequency block and a 1.5 MHz frequency block; and (2) overlapping licenses assigned to two 2.5 MHz blocks. Although Space Data concludes that an exclusive license assignment is the better approach, it also concludes that market forces may be the best judge for how the ATG licenses ultimately are assigned. Specifically, the ATG auction can be designed so that the bidders determine whether exclusive licenses or overlapping licenses represent the highest and best use of the 4 MHz of spectrum available in the ATG band. The ATG spectrum can be divided into four frequency blocks to be auctioned. Combinatorial bidding would allow bidders to purchase exclusive or shared licenses. Figure 7 describes the four block scheme in detail.

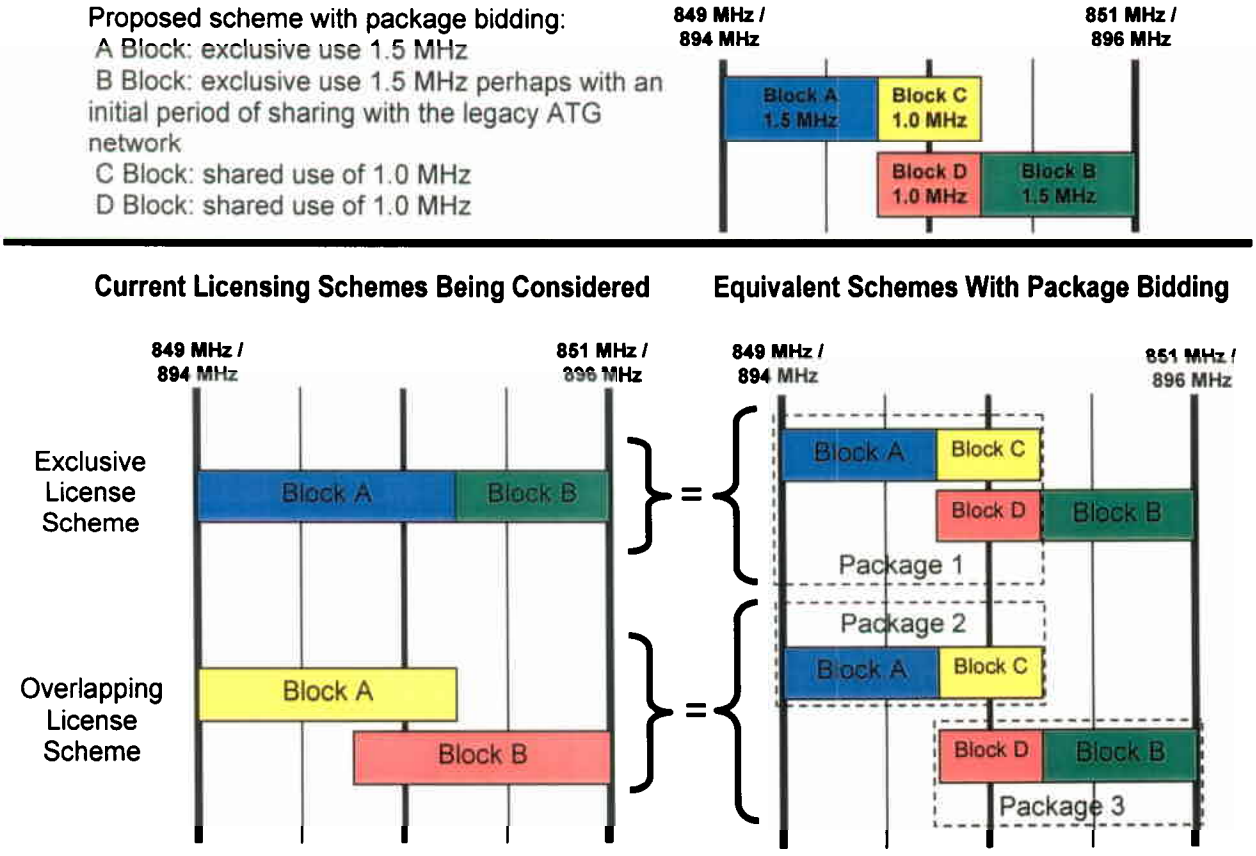

Figure 7: Proposed licensing scheme of four blocks, which through combinatorial bidding can be combined by bidders to form either of the two licensing schemes currently under consideration.

The A Block could be an exclusive and unencumbered license if the legacy ATG operations on this spectrum are moved to the B Block 1.5 MHz exclusive license prior to the auction. The B Block is a 1.5 MHz exclusive use license, but it would share spectrum with the legacy ATG network for a limited period of time. Block C and Block D both share the same 1.0 MHz of spectrum at the center of the ATG allocation.

A package bidding auction format, similar to the one successfully employed in Auction No. 51, would allow a bidder to bid only on a combination of licenses that have certain synergies without the risk of becoming high bidder on one or more licenses without winning the whole package. For example, if one bidder was interested in an exclusive use 2.5 MHz license, it could bid on Package 1 consisting of A Block, C Block and D Block. A Package 1 winner would be licensed for both the shared blocks and by definition the second winning bidder would be licensed for a 1.5 MHz exclusive license. This outcome would not require the application of frequency sharing rules. If a bidder wanted an overlapping 2.5 MHz license, it could bid on Package 2 consisting of A Block and C Block or Package 3 consisting of B Block and D Block. The advantage of Package 2 is that the 2.5 MHz overlapping license in Package 3 must share with the legacy ATG network for a defined period of time. A bidder also would be allowed to bid on each of the individual four blocks. To ensure competition in the ATG band, cross-ownership restrictions must be imposed upon the A Block and B Block exclusive licenses.

A package bidding approach allows both licensing schemes under consideration while eliminating any unnecessary restrictions on the 2.5 MHz overlapping scheme.[27] Specifically, the current proposal in this proceeding for two 2.5 MHz overlapping licenses suggests that the sharing rules would apply to the combined block (*i.e.*, Blocks A and C), when only 1.0 MHz of the block (*i.e.*, Blocks C and D) is shared. These sharing rules may work if CDMA technology is used because a CDMA channel would occupy the entire block (*i.e.*, Blocks A and C). However, a licensee of an overlapping block (*i.e.*, Blocks B and D) should have the technical flexibility to implement an alternative wireless technology on the 1.5 MHz of the license that is not shared (*i.e.*, Block B). For example in a 2.5 MHz overlapping license scheme, a licensee should have the flexibility to deploy a narrowband technology such as iDEN in the 1.5 MHz of spectrum that is not overlapping without coordinating with the licensee of the other 2.5 MHz block.

[27] In practice, package bidding auctions with large numbers of licenses are complex because the permutations of different packages increase the pricing computations exponentially. Space Data's proposed scheme, however, is limited to only four licenses. In Auction No. 51, the Commission successfully conducted a package bidding auction with six licenses. Thus, the infrastructure to support a combinatorial bidding auction for four licenses has been proven.

V. BOEING'S CRITICISM OF SPACE DATA'S ATG PROPOSAL IS UNSUPPORTED, INACCURATE AND SHOWS A FUNDAMENTAL MISUNDERSTANDING OF SPACE DATA'S NETWORK.

In its July 13, 2004 ex parte, Boeing dismisses Space Data's licensing proposal for the ATG band with unsubstantiated assertions that are inaccurate and misleading.[28]

A. The Use Of Stratospheric Platforms Is Not Prohibited By The Commission's ATG Rules.

Contrary to Boeing's claim, the Commission's existing rules do not prohibit the use of stratospheric platforms in the ATG band.[29] Nevertheless, the Commission initiated this proceeding to review and revise the current ATG licensing scheme to promote competition and the development of new wireless services in the ATG market.[30] The Commission recognized that the current ATG licensing scheme and technical rules do not advance competition, new services, or the use of new technologies.[31] Space Data strongly urges the Commission to adopt technologically-neutral rules in this proceeding such that ATG service providers can take advantage of all possible operational and technological efficiencies.[32] As Space Data explained in its Reply Comments and in this analysis, stratospheric platforms provide a unique, efficient, and reliable method for providing ATG services.

B. Space Data's ATG Proposal Is Safe, Reliable and Practical.

Boeing baldly asserts without any support whatsoever that Space Data's ATG proposal may be unsafe, unreliable and impractical. As shown in Appendices A and B, a stratospheric ATG network can close the return link directly from a user handset without requiring the handset to transmit at more power than the approved emission from standard wireless handsets (-23 dBm

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[28] Boeing ATG Update Report at 4 (July 13, 2004), attached to a letter from Howard J. Symons, counsel to Boeing, to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 03-103 (July 13, 2004).

[29] The Commission has recognized the benefits of stratospheric platforms and has granted Space Data a waiver to operate its balloon-borne devices as terrestrial base stations. *See Petition for a Declaratory Ruling, a Clarification or, in the Alternative, a Waiver of Certain Narrowband Personal Communications Services (PCS) Rules as they Apply to a High-Altitude Balloon-Based Communications System*, 16 FCC Rcd 16421 (WTB 2001). The use of stratospheric platforms also has been recognized at an international level. At the International Telecommunications Union ("ITU") World Radio Conference ("WRC") in 1997, the ITU created a new class of terrestrial wireless platform called High Altitude Platform Stations ("HAPS"), to cover telecommunications services provided by aerial platforms operating above 20 km (65,000 feet) in altitude. At this and subsequent WRCs held every several years, the frequency allocations for HAPS, and country access to these allocations, have expanded significantly.

[30] *See ATG NPRM*, 18 FCC Rcd at 8389.

[31] *Id.*

[32] Space Data also urges the Commission to allow the ATG band to be used on a secondary basis to provide wireless services to rural and underserved areas. Such secondary use would only be deployed if it did not cause harmful interference to the provision of wireless services to airborne customers.

in the case of CDMA). Thus, the emissions to the human body are the same for the proposed ATG system as for cellular, PCS, or ESMR customers using handsets on the ground, making the system as safe as standard CMRS handsets.

Furthermore, Boeing erroneously claims that shielding of an aircraft fuselage could prevent off-board communications. It is well known that an aircraft would not shield off-board communications (as demonstrated by the wireless calls that were placed by airplane passengers during the events of September 11). Stratospheric platforms can be used to provide ATG services whether an on-board network is installed on an aircraft or passengers use their personal wireless phones (in the event that the Commission and the FAA modify their rules to allow the on-board use of these devices). If the FAA does not modify its rules to permit on-board use of personal wireless phones, the cellular phone circuitry can be readily repackaged to extend its frequency range of operation from 25 MHz to 27 MHz, and gain FAA approval of this equipment for a cabin-mounted approach.

The Commission's stated purpose in this proceeding is to increase competition in the ATG market. Real competition, however, will continue to be limited unless airline passengers have the ability to use their personal wireless devices.[33] As explained below, in the event that the FAA modifies its existing rules to allow the use of personal wireless devices on airplanes, handsets can be modified easily to allow airborne communications. Even if the FAA does not lift these restrictions, inexpensive handsets still can be developed and manufactured to operate only on aircraft.

Although Space Data's approach requires some modifications to standard CMRS handsets to enable their use on the ATG band, handset manufacturers can be expected to make these modifications given the relative simplicity of the modifications and the size of the market when compared to other specialized handsets that are produced today. Specifically, three modifications are required to make a CMRS handset compatible with the ATG band: (1) the frequency range of operation of the handset must be expanded to encompass the adjacent ATG band; (2) the handset must adjust for the Doppler shift due to the aircraft's higher relative speed when compared to the speed of terrestrial transportations that handsets already support; and (3) the handset must be able to sense that it is on an aircraft so that it can automatically transition to the ATG band and lock out transmissions on the adjacent terrestrial bands.

The first modification can be accomplished by simply extending the range of operation of cellular or ESMR handsets.[34] Cellular handsets are designed to receive and transmit over a 25 MHz x 2 range of frequencies. Because the ATG band is directly adjacent to the cellular band, a standard cellular handset need only be extended from 25 MHz to 26.25 MHz to encompass the staff's proposed A Block ATG license, an extension of only five percent of the current operating range. Dual-band ESMR handsets operate in both the 800 MHz band and the 900 MHz band and are widely deployed (approximately 50 percent of Nextel's installed base of 14 million

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[33] *See* Reply Comments of Space Data at 8 (noting that without flexibility to use personal wireless handsets, consumers are restricted to using the ATG services of the carrier whose equipment is installed on an airplane).

[34] PCS phones also can be modified to allow access to ATG spectrum, but the process is somewhat more complex because PCS-only phones do not operate on adjacent frequencies.

handsets).[35] These handsets already have the circuitry to transmit at 896-901 MHz and receive at 851-869 MHz. Thus, modifying the transmit range to 895.25-901 MHz and the receive to 850.25 MHz-869 MHz to encompass the staff's proposed 1.5 MHz B Block ATG license is a small four to 15 percent increase in operating range.

The second modification requires the tracking of Doppler shifts, which are higher in ATG than in terrestrial CMRS networks. At a speed of 950 km per hour (263 meters per second) the Doppler shift at 900 MHz is:

900,000 kHz * (263 / 300,000,000) = 0.8 kHz.

The 0.8 kHz is only 3.2 percent of the width of an iDEN channel and 0.06 percent of the width of a CDMA channel. The modern phase lock loops employed in CMRS handsets likely can track this level of frequency shift, although minor software modifications may be required.

The final modification requires the handset to sense when it is in an aircraft. Using the Doppler shift from the second modification, a handset could implement software lockouts, such that when the frequencies of CMRS base stations are shifted by more than a certain amount the handset can assume that it is moving at a high rate of speed and in an aircraft. If this condition is sensed, the software would enable the ATG range of operation and lock out operation on the CMRS bands. ATG operation could work when a handset is in a terrestrial environment outside of tower coverage. With no base stations available, it could be allowed to use the ATG channels. This would allow secondary use of the ATG coverage to terrestrial users when in remote locations beyond CMRS coverage.

Handset manufactures currently make special handsets with more extensive modifications than those required to support the ATG operations for much smaller markets. For example, Motorola has developed the i2000 handset which operates on the iDEN protocol on ESMR bands (806-824 / 851-869 MHz) and the GSM protocol on international 900 MHz GSM bands (890-960 / 935-1005 MHz). World phones for cellular operators[36] include GSM phones that operate on tri-band (900/1800/1900) or quad-band (850/900/1800/1900), and Samsung and Motorola have introduced handsets that roam between GSM and CDMA networks.[37] World phones are required to operate on completely different bands and in some cases implement multiple protocols, which are much more extensive modifications than required to enable a handset to operate on the ATG band. Yet the potential market for these world phones, which are limited to international travelers, is a fraction of the market potential for an ATG-enabled CMRS handset.[38] Thus, if the handset manufactures find it profitable to build world phones that require

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[35] *See* "NXTL: What's Next? $30 More Likely Than $20," Thomas Weisel Partners at 2 (Aug. 13, 2004), available at http://www.flarion.com/viewpoint/reports/TWP_NXTL081304-163133.pdf.

[36] *See, e.g.,* Editor's Top Wireless World Phones, available at http://reviews-zdnet.com.com/4521-6525_16-5021435-7.html (reviewing world phones).

[37] *See* "Verizon Offers CDMA-GSM World Phone" (Sept. 1, 2004), available at http://nwc.mobilepipeline.com/showArticle.jhtml?articleID=46200443.

[38] In 2000, only 53 million Americans took trips overseas compared to the 605 million airline trips that occurred domestically that year. Thus, the ratio of annual U.S. domestic flights to international flights is approximately 11 to 1.

extensive modifications to standard handsets for the international travelers' market, they likely would find it profitable to make less extensive changes that are required to enable ATG operation for a market that is several times larger.

Boeing advocates the use of picocells onboard aircraft that interface with standard CMRS handsets. Picocells likely are impractical for several reasons. First, the picocells must be able to support all CMRS protocols and frequency bands, or risk passenger and flight attendant confusion. For example, if a cabin-mounted picocell supported only CDMA at 1900 MHz, flight attendants would have to announce that only passengers with CDMA phones can use them. Most consumers do not know their wireless phone's protocols or frequencies. In this example, passengers using GSM and iDEN handsets likely would try to contact terrestrial networks, resulting in the harmful interference. An ATG operator potentially could use cabin-mounted picocells that can accommodate all protocols (AMPS, TDMA, CDMA, iDEN and GSM). However, these picocells must operate on all the CMRS frequency bands while flying over all the wireless market areas of the country. The interference cases and spectrum rights issues related to this approach make picocells a tenuous and impractical approach.

C. Space Data's Balloon-Borne System Is An Affordable Mechanism For ATG Services.

As Space Data explained in its Reply Comments, its system utilizes inexpensive airborne weather balloons to carry miniature radio repeaters (SkySites® Platforms) to an altitude of approximately 100,000 feet. A constellation of 250 airborne balloons can provide ubiquitous ATG coverage in the continental United States at the cost of 3.1 cents per minute of use. This assumes a cost of $2556 a day to launch 250 balloons twice a day to achieve full CONUS coverage and 7.6 percent minutes of use during busy hours. Space Data's cost per minute of use is comparable to the average terrestrial wireless service provider. Boeing is wrong that Space Data's service will not be affordable and competitive with terrestrial-based ATG providers.

VI. CONCLUSION.

Space Data strongly urges the Commission to adopt an exclusive licensing scheme that allows ATG licensees to utilize a wide variety of networks and technologies to provide ATG services, including stratospheric platforms. Such flexibility would serve the public interest by promoting competition and the provision of new wireless services to airborne consumers. The Commission staff's proposal to assign two exclusive licenses in the ATG band would be technologically neutral and permit ATG operators to use different types of networks, protocols and technologies to provide the most efficient and effective ATG services to consumers. An overlapping license scheme, on the other hand, would necessitate the development and implementation of considerable sharing rules, and prevent the technological flexibility that would encourage competition in the ATG market.

APPENDIX A

CDMA LINK BUDGET FOR A MINIMAL CAPACITY STRATOSPHERIC ATG NETWORK

DESCRIPTION	VALUE	UNITS	NOTES
Coverage radius			
Coverage radius	500	miles	
or	[redacted]	km	
Free space loss			
Spreading Loss	[redacted]	dB/m2	
Reverse Channel Frequency	896	MHz	Highest reverse channel frequency
Area of an Isotrope	[redacted]	dBm2	
Free space loss	[redacted]	dB	
Passenger transmitter			
Subscriber device transmitter power	23.0	dBm	
Subscriber device antenna gain	0	dBi	Could be increased with window mount antenna to 6dB
Polarization loss and body loss	2	dB	
Window loss	5	dB	Note: phone is near or attached to window
Portable EIRP	[redacted]	dBm	
HAP receiver			
HAP antenna gain	17.0	dBi	Gain of a 5 dB sectored antenna
or	[redacted]	dBd	
Cable loss	0.5	dB	
Receiver diversity gain	0	dB	
Desired Eb/No	7.5	dB	about 1% frame error rate
Data rate	14,400	bps	Rate kSet 2
Receiver noise figure	4	dB	
Signal bandwidth	1.2288	mHz	
Receiver sensitivity	[redacted]	dBm	
Power required incident on antenna	[redacted]	dBm	
Fading and loading			
Fade margin	0.5	dB	Not a fading environment
Cell loading margin	2.83	dB	Noise added for 50% loading
Interference margin	0	dB	No outside interference at that altitude
Modified required power incident on antenna	-134.1	dBm	Minimum receive level at the SkySite™ antenna
Uplink margin outside without free space loss	[redacted]	dB	
Link margin			
Excess link margin	[redacted]	dB	

This budget shows that the link can be near a conventional cellular CDMA handset (with modifications to extend the band into the ATG spectrum) that is at the cabin window. One possible way to use ATG service under this scenario is for a passenger to attach his or her handset to the airplane window using a holster with suction cups and a hands-free accessory. The attenuation through an aircraft window is minimal and the field of view of the sky is nearly 140 degrees in this configuration. Off-board calls directly from passenger equipment would likely require more than the minimum of three stratospheric platforms (likely 6-9 platforms) to ensure that a passenger would have a continuous, direct view of a platform from windows from either side of an aircraft for all aircraft directions. Of course, this scenario would require the Federal Aviation Administration ("FAA") to permit the use of handsets on aircraft. However, if the FAA does not permit such use, the network would also work with cabin mounted equipment approved by the FAA with an antenna mounted on top of the aircraft. In this case the minimum of three stratospheric platforms could be used.

APPENDIX B

iDEN LINK BUDGET FOR A HIGH CAPACITY STRATOSPHERIC ATG NETWORK

DESCRIPTION		VALUE	UNITS	NOTES
Maximum slant range				
	HAPS altitude	120,000	feet	
	Aircraft altitude	40,000	feet	
	Protocol limited distance	70	miles	
	HAP height above aircraft	80,000	feet	
	Coverage radius	85.2	miles	
	or	137.0	km	
				Accounts for overlaping coverage and drift. Fewer HAPS are needed if relative drift is reduced or eliminated
	Approx # of HAPS to cover CONUS	301	HAPS	
Free space loss				
	Spreading Loss	[redacted]	dB/m2	
	Reverse Channel Frequency	896	MHz	Highest reverse channel frequency
	Area of an Isotrope	[redacted]	dBm2	
	Free space loss	[redacted]	dB	
Passenger transmitter				
	Subscriber device transmitter power	27.0	dBm	i1000 radio
	Subscriber device antenna gain	0	dBi	Could be increased with window mount antenna
	Polarization loss and body loss	2	dB	
	Window loss	5	dB	Note: phone is near or attached to window
	Portable EIRP	[redacted]	dBm	
HAP receiver				
	HAP antenna gain	17.0	dBi	Gain of a 6 sectored antenna
	or	[redacted]	dBd	
	Cable loss	0.5	dB	
	Receiver diversity gain	0	dB	
	Receiver sensitivity (RF input)	-112.0	dBm	RadioFrame iden receiver
	Power required incident on antenna	[redacted]	dBm	
Fading and loading				
	Fade margin	0.5	dB	Not a fading environment
	Interference margin	0	dB	No outside interference at that altitude
	Modified required power incident on antenna	[redacted]	dBm	Minimum receive level at the SkySite™ antenna
	Uplink margin outside without free space loss	[redacted]	dB	
Link margin				
	Excess link margin	[redacted]	dB	

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